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FUEL ADDITIVE

THIS INVENTION relates to fuels. In particular, the invention relates to an emulsifying composition, to a hydrocarbon fuel, and to a method of forming a hydrocarbon fuel and water emulsion.

According to the invention, there is provided an emulsifying composition which includes

an ethoxylated alkylphenol;
a fatty acid amide;
naphtha; and
oleic acid.

It is to be understood that the invention finds substantial utility as a composition for emulsifying fuel and water mixtures used in internal combustion engines, open flame burners (boilers), or the like. However, the invention is not limited to this application and may also be used in other applications such as a cleaning agent, for example, lifting oil deposits from surfaces such as tarred roads, concrete, masonry, or the like.

The ethoxylated alkylphenol is a non-ionic surfactant of general formula $R(OCH_2CH_2)_nOH$ in which R is alkylphenol and n represents the number of ethoxy groups.

The ethoxylated alkylphenol may be polyoxyethylene (POE)-nonylphenol, for example, a product available from ICI under the tradename SYNPERONIC NP. In a preferred embodiment of the invention, POE-(5) or POE(6)- nonylphenol may be used, for example, SYNPERONIC NP5 or SYNPERONIC NP6.

The fatty acid amide may be a fatty acid dialkanolamide. In a preferred embodiment of the invention, the fatty acid amide may be coconut diethanolamide, for example, a product available from Albright & Wilson under the tradename EMPILAN 2502.

The naphtha may be heavy naphtha.

In a preferred embodiment of the invention, the composition may include polyoxyethylene-nonylphenol, coconut diethanolamide and heavy naphtha. Preferably, the composition may contain one part polyoxyethylene -nonylphenol, two parts coconut diethanolamide, two parts heavy naphtha and one part oleic acid, by volume.

The invention also extends to a hydrocarbon fuel including a composition in accordance with the invention.

The hydrocarbon fuel may be an alcohol based fuel, gasoline (petrol), diesel fuel e.g. sweet diesel, or mixtures thereof.

The hydrocarbon fuel may include up to about 40% water, by volume. Preferably, the hydrocarbon fuel may contain up to about 25% water.

The hydrocarbon fuel may include between about 1.5% and 2%, by volume, of the composition.

According to another aspect of the invention, there is provided a method of forming a hydrocarbon fuel and water emulsion which includes adding an ethoxylated alkylphenol, a fatty acid amide, naphtha and oleic acid to a hydrocarbon fuel to form a mixture and adding water to said mixture.

Preferably, the method includes forming an additive composition containing the ethoxylated alkylphenol, the fatty acid amide, the oleic acid and the naphtha and adding said additive composition to the hydrocarbon fuel.

Preferably, a composition including one part polyoxyethylene-nonylphenol, two parts coconut diethanolamide, one part oleic acid and two parts heavy naphtha, by volume, is added to the hydrocarbon fuel to form the mixture.

Advantageously, the constituents of the additive are mixed in the order polyoxyethylene-nonylphenol, coconut diethanolamide, oleic acid and naphtha to form the composition.

The invention will now be described, with reference to the following non-limiting examples and tests.

EXAMPLE 1

A batch additive composition in accordance with the invention containing one part polyoxyethylene -nonylphenol (SYNPERONIC NP5 or 6), two parts coconut diethanolamide (EMPILAN 2502), one part oleic acid and two parts heavy naphtha was prepared. These components were mixed in the order stated above. 1.8 litres of the batch composition was added to 71.79 litres (15.792 imperial gallons) of a base hydrocarbon fuel. The base fuel used was a 70 - 30 blend of No. 5 fuel oil containing 70% Bunker C fuel and 30% diesel fuel, by volume. The mixture of the composition and base fuel was agitated using compressed air and was left for approximately 2 - 5 minutes to allow dispersion of the composition and the fuel oil. Thereafter, 23.93 litres (5.264 gallons) of water was added to the mixture. The resultant mixture was agitated using compressed air for approximately 2 - 5 minutes to allow the fuel/water emulsion to form. If necessary, a second agitation may be carried out after 20 minutes. As will be appreciated from the above volumetric amounts the resultant mixture contains about 25% water and about 1.86% of the composition, by volume, in the final blend.

For the purpose of the tests described below a 74.6 KW (100 horsepower) Scotch Marine Boiler with a full modulation industrial combustion Hev-e-Oil burner was used. The boiler was modified to accept fuel from two sources, namely, a main tank containing the No. 5

blend fuel oil described above (without the additive) and an auxiliary tank containing the fuel prepared in accordance with Example 1. Return lines of the boiler were re-piped to re-circulate through the main fuel oil pump and the burner bypass valve respectively. This enabled the fuel supplied to the boiler to be changed, between the two sources as required, without a return oil consideration. A series of tests were conducted using the boiler and the compositions described above, as is set out in more detail below.

TEST NO. 1

The boiler was run initially on the No. 5 fuel oil provided in the main tank until the boiler pressure reached about 344 KPa (50 pounds per square inch (psi)). Once this pressure was reached the operation of the boiler was switched over to the fuel prepared in accordance with Example 1 for an initial inspection of the flame. A smooth changeover was observed. The flame was well defined and appeared tighter and longer than the No. 5 fuel oil flame. The boiler was operating in automatic full modulating mode. The boiler was noticeably quieter in operation when the changeover occured. A steam pressure increase to about 361.7 KPa (52.5 psi) was also observed.

TEST NO. 2

The boiler was fired up using the fuel prepared in accordance with Example 1 and brought up to the operating temperature of approximately 361.7 KPa (52.5 psi). The boiler was set in manual mode at near high fire position to fix the position of all fuel air ratio linkages in order to obtain a comparison of the No. 5 fuel oil and the fuel in accordance with Example 1, under the same conditions. The boiler was not set for optimum efficiency during this run. Combustion tests were conducted on both fuels using an Enerac 2000 combustion analyzer which measured carbon dioxide, carbon monoxide, combustible gas, excess air and oxygen emissions. These results are set in Table 1 below. The test results show a reduction in carbon dioxide, carbon monoxide and combustible gas emissions using the fuel in accordance with the invention, despite an increase in excess air and oxygen.

TEST NO. 3

A steam flow capacity test was conducted. In order to do this a flow meter was installed between the feed water supply pump and the boiler. The boiler was run on the fuel in accordance with Example 1 and was brought up to an operating pressure of approximately 379 KPa (55 psi). The steam capacity was randomly measured at about 832.6 kg per hour (1834 pounds per hour). This was calculated by measuring the amount of water entering the boiler using the flow meter over a predetermined period and by relying on the accepted relationship between mass and gallons of water evaporated in the boiler industry i.e. that the

mass of steam in pounds per hour divided by 500 is equal to the gallons of water per minute evaporated.

TEST NO. 4

The steam flow capacity of the fuel in accordance with Example 1 was compared with that of the No. 5 blend oil. A fixed fire held in place by placing the boiler in manual operating mode was achieved. The results of this test showed that the fuel in accordance with Example 1 generated steam at a rate of about 1114.7 kg/h (2235 pounds per hour) based on evaporating about 345.4 litres (76 gallons) of water in 17 minutes and the No. 5 fuel oil generated steam at a rate of about 983.8 kg per hour (2167 pounds per hour) based on evaporating about 295.4 litres (65 gallons) of water in 15 minutes. The average stack temperatures were measured at approximately 265.6°C (510°F) for the fuel in accordance with Example 1 and approximately 246.1°C (475°F) for the No. 5 fuel oil.

TEST NO. 5

A stability test to observe the emulsifying characteristics of the fuel in accordance with the invention was conducted. A batch of fuel prepared in accordance with Example 1 was left for approximately 6 days and then the boiler was fired up. A clean burn was observed without any indication of fuel separation. An additional 22.7 litres (5 gallons) of fuel in accordance with Example 1 from a separate batch was added to the auxiliary tank during this run. There was no visual indication of separation while the additional fuel was being added and there was no

difference in the flame in the burner. The boiler was run until the entire fuel batch was depleted.

TEST NO. 6

A further emission test was conducted by running the boiler near optimum efficiency. The test was started on a No. 5 fuel oil batch and then the boiler was changed over to a fuel prepared in accordance with Example 1 without any adjustments in the fuel/air ratio. The emissions of oxides of nitrogen and sulfur dioxide were measured using the Enerac 2000 analyzer and the combustion efficiencies were calculated. The results are set out in Table 1 below.

TABLE 1 - A comparison between the fuel in accordance with the invention and the No. 5 fuel oil.

	FUEL IN ACCORDANCE WITH EXAMPLE 1	NO. 5 FUEL OIL
Combustion Efficiency	74.9%	83.5%
Ambient Temperature	32.2°C (90°F)	28.9°C (84°F)
Stack Temperature	260.6°C (501°F)	255.6°C (492°F)
Oxygen	9.3%	5.7%
Carbon Monoxide	16 ppm	77 ppm
Carbon Dioxide	9.0%	12.2%
Combustible Gases	0.39%	0.00%
Excess Air	76.0%	34.0%
Oxides of Nitrogen	95 ppm	120 ppm
Sulphur Dioxide	708 ppm	880 ppm

TEST NO. 7

A comparative test was conducted to determine the amount of fuel consumed to produce a given quantity of steam for both fuels. Each test was started immediately after feed water supply pump was shut off and the fuel valve was simultaneously opened. The starting time was noted and the water supply reading was noted. Each test was conducted using 23.9 litres (5.264 gallons) of the fuel. Each sample was weighed beforehand. Each test was stopped by shutting off the fuel valve and noting the time at a later feed water supply shut off. The feed water pump was controlled automatically through a MacDonnel Miller No. 157 assembly that engaged the pump at a fixed low water point and disengaged the pump at a fixed high water point. The test results are set out in Table 2 below.

TABLE 2.- Comparative fuel consumption tests.

PARAMETERS	FUEL IN ACCORDANCE WITH EXAMPLE 1	NO. 5 FUEL OIL
Weight of Fuel per Gallon	3.73 kg (8.21 lbs)	3.69 kg (8.12 lbs)
Fuel used per Minute	1.56 kg (3.44 lbs)	1.58 kg (3.47lbs)
Volume of Fuel used per minute	1.95 litres (0.43 gal)	1.91 litres (0.42 gal)
Duration of Test	13 min	10.25 min
Volume of Water Supplied	209.1 litres (46 gal)	150.1 litres (33 gal)
Steam Generating Rate lbs/hour	803.6 (1770 lbs/hour)	730.94 litres (1610 lbs/hour)
Mass of Steam Generated per Minute	13.39 kg (29.50 lbs/hour)	12.19 kg (26.84 lbs)

EXAMPLE 2

A fuel in accordance with the invention was prepared in a similar fashion to Example 1 except that the composition was mixed with diesel fuel instead of the No. 5 blend fuel oil. A series of bench tests on an internal combustion engine - RICARDO P6 Diesel fuel test engine were carried out using the fuel in accordance with the invention. A similar bench test was carried out using a diesel fuel control sample. The results of the control sample test and the test on the fuel in accordance with the invention are set out in Tables 3 and 4.

TABLE 3 - Diesel Fuel Control Test - Ambient temperature 25°C. Atmospheric pressure 76.70 (Cm.HA).

SPEED (RPM)	BALANCE LOAD (kgs)	POWER (KW)	50ML FUEL CONSUMED (SECS)	FUEL FLOW RATE (litres per hour)	SFC (L/KW.HR)	BMEP (KN/M^2)	EXHAUST TEMP (°C)
800	4.54 (10.00 lbs)	1.78				504.34	401.00
1000	4.40 (9.70 lbs)	2.07				489.21	422.00
1200	4.79 (10.55 lbs)	2.70	95.97	1.88	0.70	532.08	452.00
1400	5.27 (11.60 lbs)	3.46				585.03	488.00
1600	5.47 (12.05 lbs)	4.11				607.73	509.00
1800	5.76 (12.70 lbs)	4.87	62.10	2.90	0.68	640.51	512.00
2000	5.99 (13.20 lbs)	5.63				665.73	536.00
2200	6.04 (13.30 lbs)	6.23				670.77	549.00
2400	5.90 (13.00 lbs)	6.65	43.85	4.10	0.62	655.64	566.00

<u>TABLE 4</u> - Test on fuel in accordance with the invention - Ambient temperature 25°C - Atmospheric Pressure 76.70 (CM.HA)

SPEED (RPM)	BALANCE LOAD (kgs)	POWER (KW)	50ML FUEL CONSUMED (SECS)	FUEL FLOW RATE (litres per hour)	SFC (L/KW.HR)	BMBP (KN/M²)	EXHAUST TEMP (°C)
800	5.65 (12.45 lbs)	2.12				629.90	344.00
1000	5.79 (12.75 lbs)	2.72				643.03	374.00
1200	5.81 (12.80 lbs)	3.27	95.65	1.88	0.57	645.55	403.00
1400	5.95 (13.10 lbs)	3.91				660.68	422.00
1600	5.92 (13.05 lbs)	4.45				658.16	439.00
1800	6.08 (13.40 lbs)	5.16	62.75	2.87	0.56	678.43	461.00
2000	1.77 (13.90 lbs)	5.92				701.03	504.00
2200	6.36 (14.00 lbs)	6.56				706.07	532.00
2400	6.24 (13.75 lbs)	7.03	44.75	4.02	0.57	693.47	547.00

The results indicate similar to slightly less fuel consumption rates for the fuel in accordance with the invention when compared with the control fuel over a range of rpm values but with an increase in power

output. The exhaust temperatures are also shown to be less in Table 4 as compared with Table 3. Unburnt deposits were also at least reduced when the engine was run on the fuel in accordance with the invention.

The Applicant believes that it is an advantage of the invention that the composition in accordance with the invention provides a relatively cost effective fuel extender for internal combustion engines, marine boiler applications i.e. open flame burners, or the like. The constituents used in the composition are readily accessible at relatively low cost and are easily cold mixed. The selection of the four constituents enable effective results to be achieved by adding relatively small quantities of the composition to the fuel with significant water additions (Typically 3:1 fuel to water). The Applicant also believes that no significant adjustment in quantities of the composition are required over a range of light to heavy fuels. The Applicant believes that it is a further advantage of the invention that the final blend is a stable emulsion which shows no signs of settling over sustained periods.

The Applicant also believes that it is an advantage of the invention that the composition provides a relatively clean burning and, therefore, environmentally friendly fuel. The oxides of nitrogen and sulphur, carbon monoxide and carbon dioxide contents are reduced as compared to fuels not containing the composition. In addition, oxygen content and excess air evident in the exhaust emissions show substantial increases and there is also a substantial reduction in smoke or unburnt carbon.

The Applicant also believes that the fuel in accordance with the invention improves engine life as a result of the drop in exhaust temperatures.

It is a further advantage of the invention that the composition is odourless, non-acidic, non-toxic and, therefore, does not harm the skin if handled. In addition, the flash point of the composition is substantially the same as the fuel with which it is mixed and, therefore, safety aspects in handling and transportation are not compromised by including the composition in a fuel.

The Applicant also believes that the composition may be directly substituted for normal hydrocarbon fuel subject to possible minor adjustments to air and fuel flows to optimise performance.

Internal combustion engines which have been running on normal diesel fuel experience carbon build-up and other fuel derived deposits. The Applicant believes these may be broken down and exhausted when the engine is run on fuels including the composition in accordance with the invention. Even after prolonged usage, engine components, particularly fuel pump components exhibit no adverse wear or corrosion and older engines appear to run more smoothly.

For a given rpm the test in Example 2 showed that the engine running on the fuel in accordance with the invention required comparative to slightly less fuel flow rates to the diesel fuel and, at which flow rate, the power output increased. The exhaust temperature also significantly decreased. It is also believed that the lower rpm for the

same power output and a lower operating temperature contributes to an improvement in engine life.

The Applicant also believes that the problem of oil spill disasters may be alleviated by including the composition in bulk volumes of fuel transported on tankers. The emulsifying properties of the composition would alleviate the problem of oil slick formation in water.